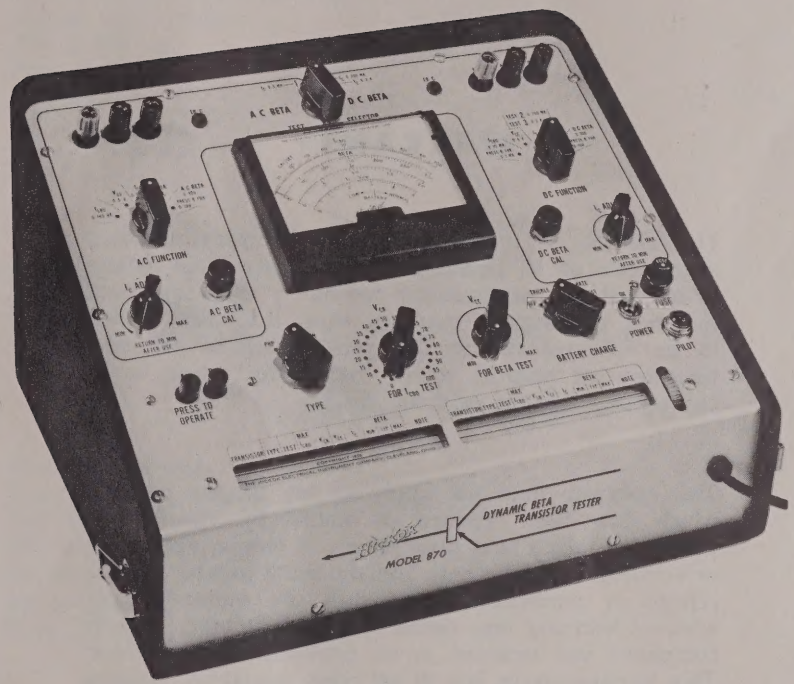

Model 870, Dynamic Beta Transistor Tester

MODEL 870
DYNAMIC BETA TRANSISTOR TESTER

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This warranty does not apply to any of our products which have been repaired or altered by unauthorized persons, or which have been subject to misuse, negligence, or accident, or which have had the serial number altered, effaced or removed. Neither shall the warranty apply where a warranty registration card has not been properly completed and returned to us promptly after purchase. This warranty is in lieu of all other warranties whether expressed or implied.

RETURNING EQUIPMENT FOR REPAIR

Before returning any equipment for service, the factory must first be contacted, giving the nature of the trouble. Instructions will then be given for either correcting the trouble or returning the equipment. Upon authorization, this equipment should be forwarded directly either to the Hickok factory address at 10514 Dupont Avenue, Cleveland, Ohio, 44108, or to a designated service station in your locality.

19120-153

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TECHNICAL DATA

I. 1. Power Supply requirements: 105-125V, 50-70 cps AC

2. Power Consumption: 35 watts at 115V

3. Meter Scales:

I_{CBO}	0-100
BETA	0-100 0-300
I_C	0-2 0-5
V_{CE}	0-5

4. Ranges:

I_{CBO}	0-100 μa 0-1 MA 0-10 MA
V_{CE}	0-5 V
I_C	0-5 MA 0-200 MA 0-2 A

5. Meter

Sensitivity - 100 μa, 100 MV

6. AC Test Signal

1000 cps sine wave, variable from 2.5 μa to 10 μa
Calibration setting at 5 μa

7. Tube Complement

	Tube	Function
V1	6X4	Power Rectifier
V2	OB2	Voltage Regulator
V3	12AT7	1/2 - 1000 cps phase shift oscillator 1/2 - cathode follower
V4	6AW8	AC Bridge

II DESCRIPTION

II. 1. Purpose

The Hickok Model 870, DYNAMIC BETA TRANSISTOR TESTER, is designed to test all small, medium power, and power transistors under typical operating conditions. The versatile features of the Model 870 permit an excellent test of switching type transistors.

2. General Description

The Model 870 offers the features of two separate transistor test instruments:

a. An AC BETA TESTER (Small Signal Test)
b. A DC BETA TESTER (Medium and Large Signal Test)

For ease of operation the front panel of the instrument has been divided into two major sections. The AC BETA section on the left side, and the DC BETA section on the right side of the front panel. Each section is clearly marked by a surrounding borderline. All receptacles and controls pertaining to each section are grouped within this area.

All operating controls common to both the AC and the DC section are located outside of the borderlines.

The instrument may be operated with any data taken from a transistor handbook, specification sheet or chart.

For quick and convenient reference, a rollchart listing all essential test information has been included in the instrument. For a small fee, replacement charts will be made available.

A large meter, the dials of which are clearly marked, permits excellent readability. All parameters are made variable over a wide range to make the Model 870 a versatile, reliable and accurate test instrument.

3. Functional Description

The Model 870 is designed to perform the following functional tests:

a.	I_{CBO}	Collector cutoff current
b.	AC BETA	Small signal current transfer ratio at 1000 cps
c.	DC BETA	DC current transfer ratio
d.	I_{CEO}	Collector leakage currents
e.	I_{CES}	
f.	I_{CER}	
g.	$V_{CE(sat)}$	Collector saturation voltage
h.	AC Input Impedance at given operating point	

III THEORY OF OPERATION

III. A thorough understanding of the theory behind the operation of any instrument will enable the user to obtain greater utility and satisfaction from the instrument. For this reason a brief description of the principal circuits of the instrument and diagrams of the basic test circuits are given.

1. The power supply:

To meet the rather complex power requirements of the Model 870, the power supply consists of 3 sections.

a. The intermediate voltage supply
b. The low voltage supply
c. The charging circuit

(1) The intermediate voltage supply consists of the power transformer, a rectifier tube, type 6X4, a 1N1695 silicon rectifier, two pi-type filter networks and an OA2 regulator. The latter is installed to assure good stability of the highly sensitive AC Bridge circuit.

(2) The low voltage supply employs two nickel cadmium rechargeable batteries, 5V 0.800 at 6 volts and a 5V 0.080 at 6 volts of nominal voltage. These batteries are used to give excellent reliability and long life.

(3) The charging network consists of the charging transformer T2, an SD91 silicon rectifier and four resistors, R56, R60, R61 and R62 which filter and limit the charging current.

2. The Audio Oscillator:

The AC test signal is generated by a phase shift oscillator using 1/2 of V3, 12AT7. This signal is fed into an impedance converter, cathode follower, stage which utilizes the other 1/2 of V3.

3. The AC Bridge:

The AC Bridge circuit consists mainly of two high gain amplifier stages, (6AW8), and a crystal diode bridge detector. The circuit is highly degenerative to provide for excellent stability. The input sensitivity of the bridge amplifier is 50 MV P-P or 17.6 MV RMS for full deflection of the meter.

4. The Metering Circuit:

The indicator used in the Model 870, a 66K type meter, has a sensitivity of 100 μa, with an internal resistance of 1000 ohms. For the purpose of meter protection against overloading, a silicon diode, type SD91, is connected across the meter terminals. This diode will conduct and bypass any excess current that would cause damage to the meter.

5. Selectors and Controls:

a. Test Selector

As mentioned in the general description, the tester has been divided into an AC BETA section and a DC BETA section. The setting of the TEST SELECTOR makes the choice between the AC BETA test on the left side of the instrument (position 1) or DC BETA test on the right side of the instrument panel. (Position

2 and 3). The TEST SELECTOR in position 1 activates the AC BETA test section while disabling the DC BETA test section. The TEST SELECTOR in position 2 or 3 disables the AC BETA test section.

b. Type Selector

The TYPE SELECTOR is a reversing switch which changes the polarity of the voltages applied to the transistor under test.

c. V_{CB} Selector

The V_{CB} switch is a step selector which varies voltage between collector and base in equal steps of 5V from 0-100V. The V_{CB} selector is used for the I_{CBO}, I_{CEO}, I_{CES} and I_{CER} test only.

d. Battery Charge Selector

The battery charge selector controls the charging of the nickel cadmium batteries used as the collector and base voltage source. In the OFF position of the BATTERY CHARGE selector the charging network is disconnected. In the TRICKLE position the batteries are charged at a low rate, at which the batteries will be maintained in a fully charged state. The trickle charge may be left on indefinitely. The HIGH RATE position is for recharging purposes only. In the TEST position of the BATTERY CHARGE selector a test of the battery voltage is obtained. NOTE: See charging instruction on page 16.

e. Operate switch "A".

The push button "A", PRESS TO OPERATE, is the actuating switch for the tests. No test voltage to any element of the transistor under test is applied until the push button "A" is depressed. All settings preparing the instrument for a test can be made without any danger of damaging the transistor to be tested by any accidental missetting.

f. Push button switch "B".

Push button "B" actuates a dividing network which increases the sensitivity of the indicating network and thus changes the ranges of the meter. The changes performed by the pushbutton switch "B" are:

	From	To
BETA	0-300	0-100
I_{CBO}	0-10 MA	0-1 MA

NOTE: Unless otherwise noted all controls discussed below pertain to both the AC and DC BETA sections.

g. AC and DC FUNCTION Selectors

The AC or DC FUNCTION selector gives choice of the 5 test positions, I_{CBO}, V_{CE}, I_C, BETA CAL and AC or DC BETA. The limits of the respective ranges are marked in each position of the FUNCTION selector.

h. I_C ADJ. control

The I_C ADJ. control varies the current in the base circuit and thus controls the

current flowing in the collector circuit. The current circulated in the collector circuit is indicated by the meter and is read on the I_C dials. The I_C ADJ. controls shall be operated only when the FUNCTION selector is in the I_C position.

i. AC-DC BETA CAL control

This control is to be operated only when the respective function selector is set to the CAL position. The AC BETA CAL control calibrates the AC test signal necessary for the AC BETA test. The DC BETA CAL control sets the metering circuit to the proper sensitivity. The calibration point for both the AC and the DC BETA CAL is a set line located at 20% of full deflection of the meter.

6. Receptacles:

For the purpose of clear separation of the AC and the DC BETA section, two sets of receptacles have been provided. Each side has a socket for most common small transistors and a set of colored and marked terminals identified by E for Emitter, B for Base and C for Collector. The three alligator clips enable the user to quickly connect any type of transistor.

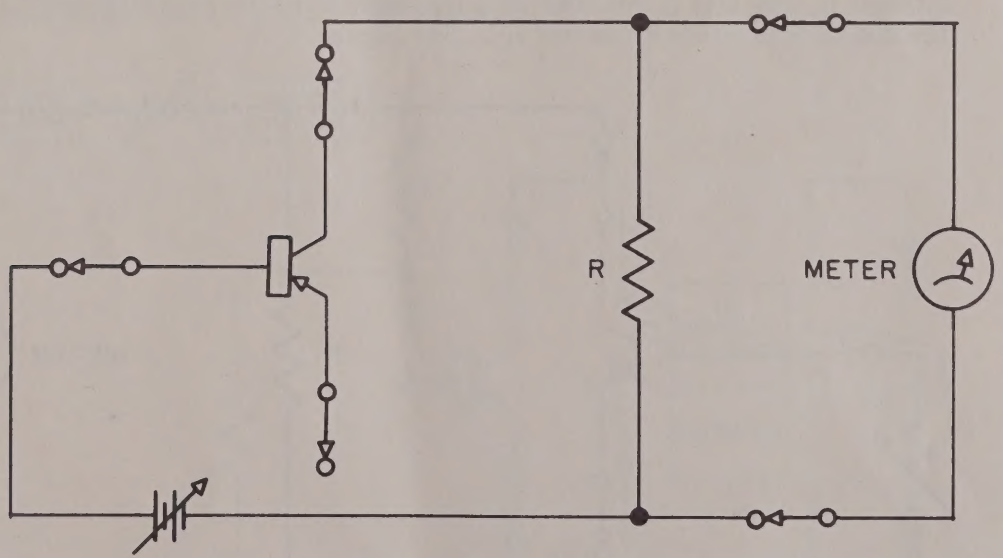
7. TEST circuits:

NOTE: To show the principle of operation, the test circuit diagrams are greatly simplified.

a. I_{CBO} Test Circuit

In the I_{CBO} test, a reverse voltage is applied between the collector and the base of the transistor under test. The emitter is open circuited.

A meter is connected in series with the collector to indicate an I_{CBO} current range of 0-100 μa. In the I_{CBO} ranges of 0-1 MA and 0-10 MA the meter is connected in parallel to a metering resistor, R. See Figure 1.

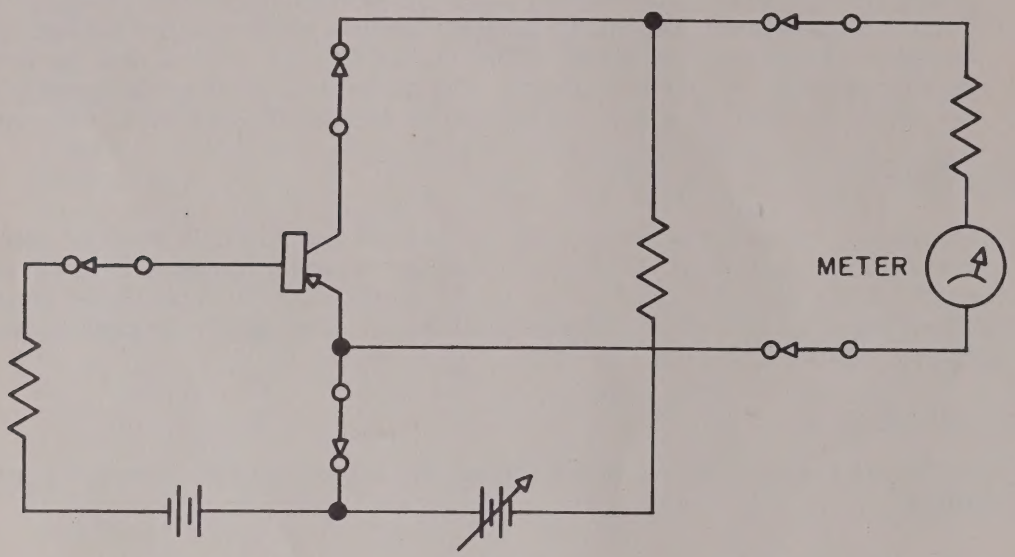


I_{CBO} (I_{CO})
TEST CIRCUIT

FIG. 1

b. V_{CE} Test Circuit

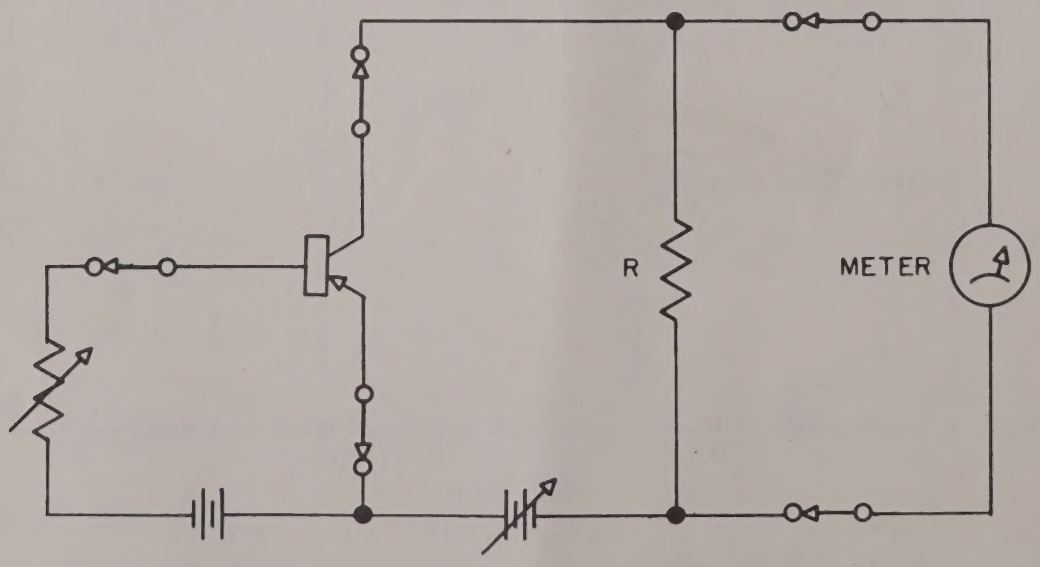
For the V_{CE} test the indicator is converted to a voltmeter to monitor the voltage between the collector and the emitter. The collector voltage is continuously variable by the V_{CE} control, the range of which is 0-5 V. See Figure 2.



V_{CE}
TEST CIRCUIT FIG. 2

c. I_C Test

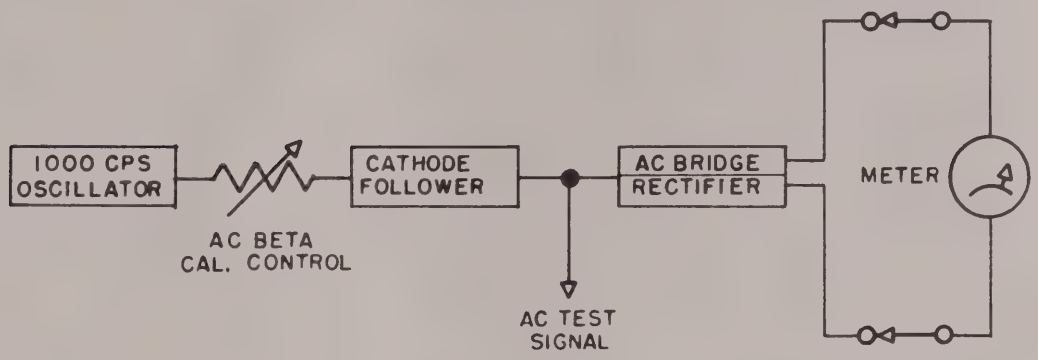
To monitor the collector current I_C, a resistor, R, is switched into the collector circuit. The voltage drop across R is measured and indicated by the meter. Since the voltage drop across R is directly proportional to the current flowing through it, the dial is marked as a function of the current to permit a direct reading of the collector current I_C. See Figure 3.



I_C
TEST CIRCUIT FIG. 3

d. AC BETA Cal.

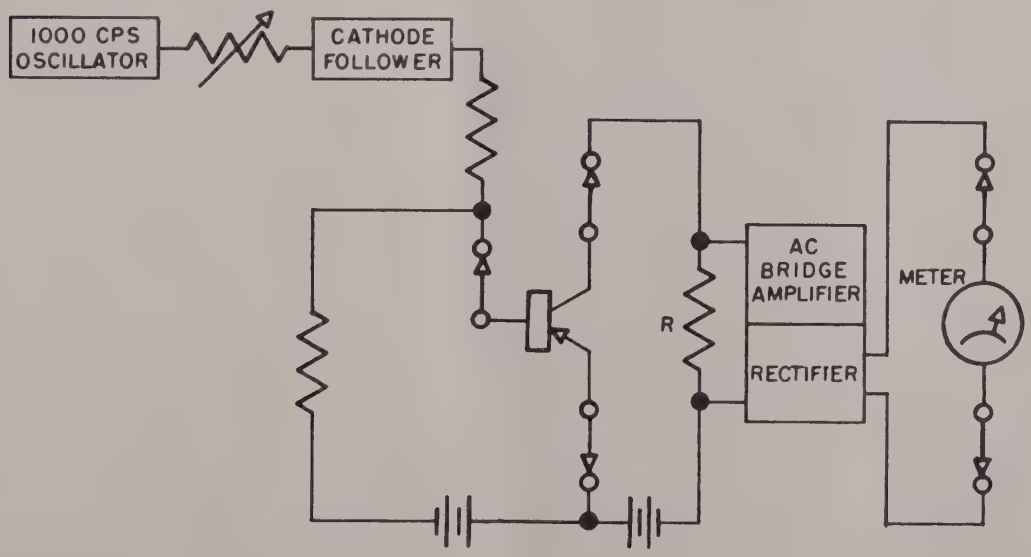
To obtain an accurate reading in the AC BETA test, the input test signal must be carefully adjusted to the calibration point. This is achieved by adjusting the AC BETA calibration control. At the calibration set line, the output of the audio oscillator is set to 1V peak to peak. In the AC BETA test the 1V, 1000 cps signal will produce a 5 μa AC current flow in the base of the transistor under test. See Figure 4.



AC BETA CAL. CIRCUIT FIG. 4

e. AC BETA Test

The calibrated 5 μa of test current circulated in the base will cause a current flow of I_B x BETA in the collector. To meter this I_C current a resistance R is connected in series with the collector. The AC signal developed across this resistor is amplified by the AC Bridge amplifier, rectified and then fed to the metering circuit. The meter dial is marked as a function of beta to permit a direct reading of the AC BETA. See Figure 5.



AC BETA TEST CIRCUIT FIG. 5

f. DC CAL and DC BETA

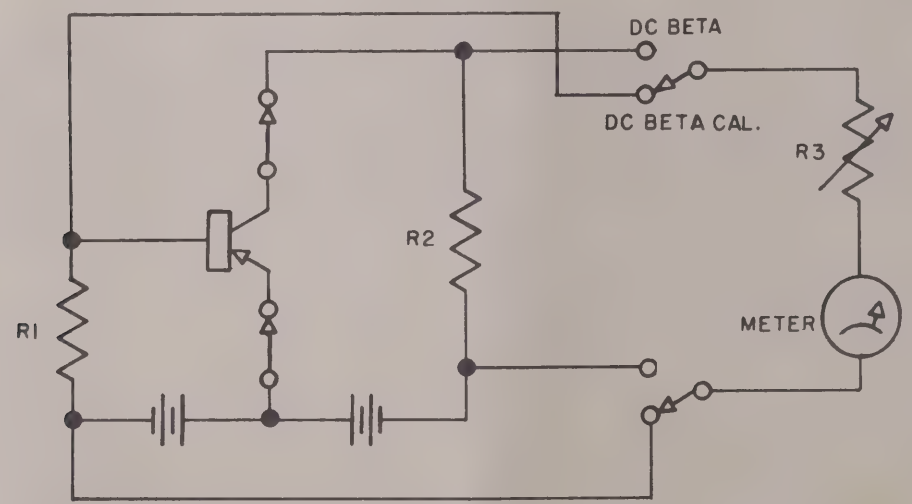
To illustrate the operation of the DC CAL and the DC BETA test circuit more clearly, the same are discussed together and will be shown in one diagram. Since the DC BETA is defined as the ratio of the collector current to the base current, the beta may be determined by comparing the collector current to the base current. A resistor is connected in series with both the base and the collector, the values of which are fixed in a known ratio. The voltages developed across these resistors are proportional to the current flowing through the same. The higher the DC BETA, the larger is the voltage developed across the collector resistance.

The meter dial is marked as a function of the DC BETA to permit a direct reading of BETA.

DC BETA CALIBRATION

As shown in the diagram in figure 6, R1 is used to monitor the base current of the transistor under test. By adjusting the potentiometer, R3, the calibration point is found by varying the sensitivity of the metering network.

To monitor the DC BETA, the metering circuit, the sensitivity of which has been set in the DC BETA CAL, is connected across the collector resistance, R2. Since the value of R2 is chosen in a known ratio to the value of R1, the meter reading obtained is the DC current ratio or the DC BETA of the transistor under test. See Figure 6.



DC BETA & DC BETA CAL.
TEST CIRCUIT FIG. 6

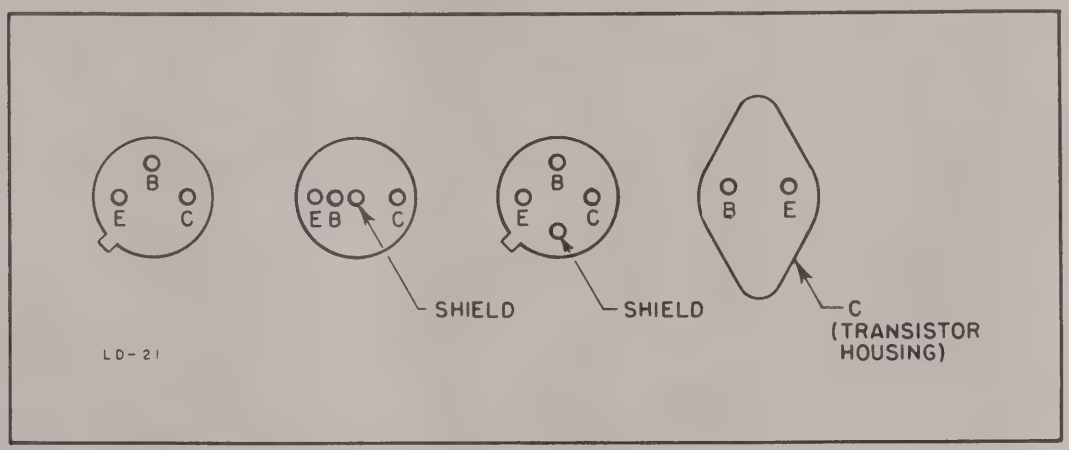
V. To prepare the instrument for operation, follow the charging instruction on page 16 of the instruction booklet.

For operation, connect the instrument linecord to a 105-125V, 60 cps AC source.

Set the power switch to the ON position and allow sufficient time for warm-up of the instrument. (Approximately 15 minutes). This will assure stable operation.

NOTE: Before attempting any specific test, the V_{CE} control, as well as the I_C Adj. controls, must be set to the 0 or minimum position to prevent any possible damage to the transistor to be tested.

For the purpose of quick reference, the bottom view of the most common types of transistors are shown in Figure 7.



1. THE ROLLCHART

To provide for a quick and reliable reference, a rollchart has been installed in the Model 870. All the essential test information is grouped and listed in logical sequence from left to right. The rollchart column heading is divided into 4 groups of information:

1. General Information
   - a. Transistor
   - b. Type
   - c. Test
2. I_{CBO} test data
   - a. Maximum I_{CBO}
   - b. V_{CB} test voltage

The maximum I_{CBO} is the highest permissible collector leakage current specified by the transistor manufacturer. Any transistor with less than the maximum I_{CBO} may be considered good in this respect.

3. Beta test data

a. V_{CE} Test voltage
b. I_C collector test current
c. Minimum) BETA
Typical)
Maximum)

The BETA of a transistor may deviate considerably from its typical value. For that reason some transistor manufacturers will give minimum or maximum limits in addition to the typical value of BETA. Others will list the minimum or typical BETA only. If the minimum BETA is not given, it may be approximated to be about 50% of its typical beta value.

4. NOTES

To test some transistors with unusual characteristics a special setup becomes necessary. The essential information for the setup will be given in the notes. The notes are designated by numbers or symbols in the note column, the meaning of which may be found at the top of the rollchart or in this instruction book.

NOTE #1	Set the "Calibration" to 40. Divide obtained "Beta" by 2.
NOTE #2	Make "I_{CBO}" test in the "AC Beta" section.
NOTE #3	Set the "calibration" to 10. Double obtained "Beta" reading.
NOTE #4	Complementary pair. PNP - identified by red NPN - identified by black dot
NOTE #5	Connect B1 and B2 to the base terminal and test as triode
NOTE #6	Perform "I_{CER}" test. Reverse the emitter and base leads. Connect a 200 ohm resistor between the emitter and base terminals.
NOTE #7	Perform "I_{CER}" test. Reverse the emitter and base leads. Connect a 30 ohm resistor between the emitter and base terminals.
NOTE #8	Perform "I_{CER}" test. Reverse the emitter and base leads. Connect a 10K ohm resistor between the emitter and base terminals.

The Principle tests performed by the Model 870 are:

1. The I_{CBO}
2. The AC BETA test
3. The DC BETA test

NOTE: In the following operating instruction, reference will be made to the rollchart installed in the instrument. However, any transistor manual may be used as test information. To operate the Model 870 with any other reference than the rollchart, refer to Page 13 in this booklet.

To make any test, perform the following preliminary steps.

A. Find the TRANSISTOR number by dialing the rollchart.
B. Set the TYPE selector to the position indicated, either PNP or NPN.
C. Set the TEST SELECTOR to position 1, 2 or 3, as indicated in the rollchart.
D. Connect the transistor to the proper terminals; use left side terminals for test #1, right side terminals for tests 2 and 3. Choose between socket, terminals or test leads, depending on the physical nature of the transistor to be tested.

1. The I_{CBO} test

By definition, the I_{CBO} (sometimes referred to as I_{CO}) is the collector leakage current with a given reverse voltage applied to the collector and the emitter open circuited. To perform an I_{CBO} test, proceed as follows:

a. Set the Function Selector of the side on which the test is performed to the I_{CBO} position.
b. Set the VCB selector to the voltage listed under the V_{CB} symbol of the rollchart.
c. Press the A button to operate and read on the I_{CBO} scale of the meter.

The ranges of I_{CBO} current are:

AC BETA	0-100 μA
DC BETA	0-10 MA
Press Button B for	0-1 MA

2. AC or DC BETA test

a. Set the FUNCTION selector (of the section at which the test is to be performed) to the V_{CE} position.
b. Press button A to operate and adjust the V_{CE} control to the voltage shown in the rollchart.
c. Set the FUNCTION selector to the I_C position.
d. Push button A and adjust the I_C control for the I_C test current given in the rollchart.

The I_C ranges are:

AC BETA TEST #1 (left side)	0-5 MA
DC BETA TEST #2 (right side)	0-200 MA
TEST #3	0-2 A

NOTE: When testing power transistors, step b and d may have to be repeated until no change as a result of a made adjustment is noticed.

e. Set the FUNCTION selector to the BETA CAL. position.
f. Press button A and adjust the BETA CAL. control to the calibration set line located at 20% of full deflection of the METER dial.
g. Set the FUNCTION selector to the AC or DC BETA position, depending on which test is performed.
h. Press button "A" to operate and read the BETA directly on the BETA scale of the meter dial.

NOTE: If the BETA is less than 100 and better readability is desired, press button B and read on the BETA range of 0-100.

Caution: Return the I_C ADJ. control to the minimum position after the test has been completed.

ADDITIONAL TESTS

The Model 870 is primarily designed to perform the basic tests, I_{CBO}, AC BETA, and DC BETA which determine the quality of a transistor. However a number of other tests which are not conventional may be performed by using the Model 870. These additional tests are:

1. I_{CEO}
2. I_{CER}
3. I_{CES}
4. AC input impedance
5. $V_{CE(sat)}$ (Collector saturation voltage

2. The I_{CEO} TEST

By definition, I_{CEO} is the collector leakage current with the collector reverse biased and the base open-circuited.

In general, the I_{CEO} leakage current is considerably larger than the I_{CBO}. To perform an I_{CEO}, proceed as follows:

a. Set the FUNCTION selector to the I_{CBO} position.
b. Reverse the emitter and base leads when connecting the transistor to the receptacle.
c. If no handbook for reference is available, set the V_{CB} selector to approximately 75% of the voltage indicated under the V_{CB} symbol on the rollchart.
d. Press button "A" to operate and read the I_{CEO} directly on the I_{CBO} dial of the meter.

NOTE: If at any time the I_{CEO} of a transistor tested in position 1 of the TEST SELECTOR (AC BETA) exceeds 100 μA, remove the transistor and test it on the DC BETA side of the instrument panel, the I_{CBO} ranges of which are 0-1 M, 0-10 MA.

3. I_{CER} TEST

By definition, I_{CER} is the collector leakage current measured with the collector reverse biased and a resistor of generally 10K connected between the base and the emitter of the transistor under test. To perform an I_{CER} test, connect a 10K ohm resistor between the base and the emitter terminals which are used for the test and proceed as if performing an I_{CEO} test.

4. I_{CES} TEST

By definition, I_{CES} is the collector leakage current with the collector reverse biased and the base shorted to the emitter.

To perform an I_{CES} test, connect a short jumper between the emitter and the base terminal and proceed as if performing an I_{CEO} test.

5. AC INPUT IMPEDANCE TEST

NOTE: The input impedance is a function of the operating condition and will vary considerably with changes of base and collector currents.

To check the AC input impedance of a transistor:

a. Prepare a network consisting of a 100 μf capacitor and a 10K ohm potentiometer in series.

b. Perform an AC BETA test as described in section V, 2 a-f and leave the test setup unchanged after completing the test.

c. Connect the network prepared in step a between the emitter and the base terminal.

CAUTION: Observe the polarity of the capacitor. When testing a PNP transistor, connect the network with the negative pole of the capacitor towards the base terminal. If a NPN transistor is to be tested, connect the positive pole to the base terminal.

d. Push button "A" to operate and adjust the 10K ohm potentiometer until the previously obtained beta reading is reduced to one half.

e. Remove the network from the terminals and measure the resistance of the potentiometer with an ohmmeter. The obtained reading is the AC input impedance of the transistor under test.

6. $V_{CE(sat)}$ COLLECTOR SATURATION VOLTAGE

By definition, the $V_{CE(sat)}$ is a collector voltage point for a given base current at which the collector current will not increase considerably when the collector voltage is increased.

NOTE: In testing switching type transistors it may be desirable to determine the $V_{CE(sat)}$.

To perform a V_{CE} test proceed as follows:

a. Perform a Beta test as described in section V, 2 a-f.

b. While pressing down pushbutton "A" turn the V_{CE} control in counterclockwise direction until the beta reading drops off sharply.

c. Locate this drop-off point (knee) as accurately as possible by adjusting the V_{CE} control slightly.

d. Set the FUNCTION selector to the V_{CE} position.

e. Press down pushbutton "A" and read the voltage on the V_{CE} dial. The obtained reading is the collector saturation voltage V_{CE} (sat) at a given base current.

OPERATING THE MODEL 870 USING TEST INFORMATION OTHER THAN THE ROLLCHART

In the preceding description of operation the rollchart installed in the instrument has been used as reference. It is understood, however, that it is impossible to include all transistors in the rollchart. To account for this fact, the Model 870 has been designed to permit any test setup by reference to test information given in handbooks, manuals or specification sheets.

When using a reference other than the rollchart simply follow the outline given by the rollchart heading using the test data from the reference book.

OPERATING HINTS

In general, the ranges of the Model 870 will suffice for the testing of transistors with normal characteristics, however, transistors with abnormal characteristics may deviate considerably from their normal values of beta, input impedance, collector and base current, etc. As a direct effect of one of those abnormal conditions, the instrument ranges may not be wide enough to permit a direct test.

To perform a test where these conditions exist, observe the following hints:

Condition 1

The calibration point cannot be reached by adjusting the CAL control.

If the CAL SET point at 20 cannot be reached by adjusting the BETA CAL control, set the CAL control to either 10 or 40 depending on which point may be reached. The Beta reading must be multiplied by 2 for a calibration setting of 10 ($\frac{1}{2}$ of original CAL setting). If the calibration has been set to 40 (twice the original setting) the obtained beta reading must be divided by 2 to determine the true beta.

For Example:

a. The calibration has been set to 2 x the indicated value:

20		2		40
Cal. Set line	X	Multiplier	=	New Set Point

The BETA reading obtained with the calibration setting of 40 is found to be 100.

To determine the correct BETA, 100 is divided by 2.

100		2		50
BETA Reading	÷	Divider	=	True Beta

b. The calibration is set to 1/2 of its original setting at 20. The set point is 10.

20		2		10
Cal. Set line	÷	Divider	=	New Set Line

The BETA reading with the calibration set to 10 is found to be 30.

The true BETA is given by the relationship

30		2		60
BETA reading	X	Multiplier	=	True BETA

As is easily seen from the examples above, the true beta varies inversely proportional to the change of the calibration from its original setting.

Condition 2

The BETA of a transistor is higher than 300 and therefore causes the meter to deflect higher than full scale.

If at any time a transistor indicates a beta of more than 300,

a. Set the FUNCTION Selector to the BETA CAL position.

b. By adjusting the BETA CAL control, set the calibration to $\frac{1}{2}$ of its CAL SET point at 20, or to 10 div.

c. Set the FUNCTION selector to the BETA position.

d. Press button "A" and determine the true BETA by multiplying the BETA reading obtained by 2.

Condition 3

The I_C test current cannot be reached by adjusting the I_C control.

If an AC BETA test is performed (position 1 of the TEST SELECTOR, 0-5 MA) and the given I_C current cannot be reached by adjusting the I_C ADJ. control, test the transistor at the highest I_C current that may be reached. If the specified I_C current is larger than 5 MA:

a. Remove the transistor from the AC BETA section and connect it to the DC BETA section.

b. Set the TEST selector to position #2, 0-200 MA, and perform a DC BETA test using the data given for the AC BETA test.

Condition 4

If a DC BETA test is performed in position #2, 0-200, of the TEST SELECTOR, and it is noted that the IC test current cannot be reached by adjusting the I_C control;

a. Set the test selector to position #3, 0-2 A.
b. Perform the DC BETA as suggested.

Condition 5

If a DC BETA test is made in position #3, 0-2A, of the TEST SELECTOR and the I_C test current cannot be reached by adjusting the I_C ADJ., test the transistor at the highest possible I_C.

In general, if conditions 3, 4 or 5 exist, it may be assumed that the BETA of the transistor under test is very low. To explain this interrelation more clearly, it should be understood that the I_C (collector current) is a function of the base current multiplied by the BETA of the transistor under test.

Since the base current is variable over a given range, the collector current will be confined to a range given by the following relationship.

$$\text{Min } I_C = \text{Min } I_B \times \text{BETA} \qquad \text{Max } I_C = I_B \times \text{BETA}$$

The ranges of base current variation by adjusting the I_C control are:

	Min	Max
Pos. 1 of the TEST SELECTOR (AC BETA section)	1.7 μa	60 μa
Pos. 2 of the TEST SELECTOR (DC BETA section)	120 μa	1.6 MA
Pos. 3 of the TEST SELECTOR (DC BETA section)	1.02 MA	40 MA

NOTE: These given limits may vary slightly because they are affected by the input impedance of the transistor under test.

7. AC BETA test signal

The AC BETA test signal used in the Model 870 is 5 μa in the Calibration setting. However, if so desired, the AC test signal may be changed to either 2.5 μA or 10 μA by either reducing the calibration to $\frac{1}{2}$ or increasing it to 2 times its usual setting. Since the BETA reading changes proportionally to the change of the test current circulated in the base, the true BETA is determined in the following way:

a. If the calibration is set to one half of its normal setting (2.5 μA), multiply BETA reading by 2 to obtain true beta.

b. If the calibration has been set to 2 x the normal setting (10 μA), divide obtained BETA reading by 2.

8. Detecting Shorted Transistors

The following inter-element shorts may develop in a transistor:

1. EMITTER to base short.
2. BASE to collector short.
3. EMITTER to collector short.

The shorts listed above may be detected by the following reactions of the tester:

1. EMITTER to base short.
   Low or no I_C reading with the I_C control set to the maximum position. Adjustment of the I_C ADJ has little or no effect on the I_C current.

2. BASE to COLLECTOR short.
   Meter will deflect full scale if an I_{CBO} test is performed.

3. EMITTER to COLLECTOR short.

   a. When attempting to set the V_{CE} voltage, a low or no reading is obtained with the V_{CE} set to the maximum position.

   b. When setting the I_C test current, a high reading is obtained which cannot be decreased by the I_C Adjust.

9. Relationship Between ALPHA and BETA

By definition:

BETA is the forward current transfer ratio of a transistor in the common emitter configuration.

ALPHA is the forward current transfer ratio of a transistor in the common base configuration.

A definite relationship between ALPHA and BETA is established in the following formula:

$$\text{BETA} = \frac{\text{Alpha}}{1 - \text{Alpha}}$$

$$\text{ALPHA} = \frac{\text{Beta}}{1 + \text{Beta}}$$

By applying one of the given formulae above, the value of one parameter (BETA or ALPHA) may be calculated if the value of the other is known.

10. Charging Instructions

To insure proper function of the Model 870, the rechargeable batteries used as the collector and the base voltage sources must be kept in a fully charged state.

To charge batteries from fully discharged state:

a. Set the BATTERY CHARGE selector to the HIGH RATE position.
b. Connect the instrument line cord to a 105-125V AC line source.
c. Allow at least 20 hours of continuous charging time to fully charge the batteries.

NOTE: The power ON-OFF switch does not activate the charging network and therefore need not be set to the ON position to charge batteries.

d. After the batteries have been sufficiently charged, set the BATTERY CHARGE selector to the TRICKLE position. This moderate charge will keep the batteries in a fully charged state.

NOTE: To assure long life of the batteries, it is favorable to keep them (once charged) in a charged state.

The TRICKLE charge may be left on indefinitely. The HIGH RATE charge is for recharging purposes only and should not be left on in excess of 60 days. Permanent damage to the batteries may result from constant overcharging. If the instrument has been inoperative for a period of longer than 1 month, recharge batteries before performing any tests.

e. To test the condition of the batteries, set the BATTERY CHARGE SELECTOR to the TEST position. The voltage indication should never be less than 6.15V or below the battery check line on the lowest arc of the meter dial.

   If the voltage is low, set the BATTERY CHARGE selector to the HIGH RATE position and allow appropriate time for recharging. After the batteries have been sufficiently charged, return the BATTERY CHARGE selector to the TRICKLE charge position.

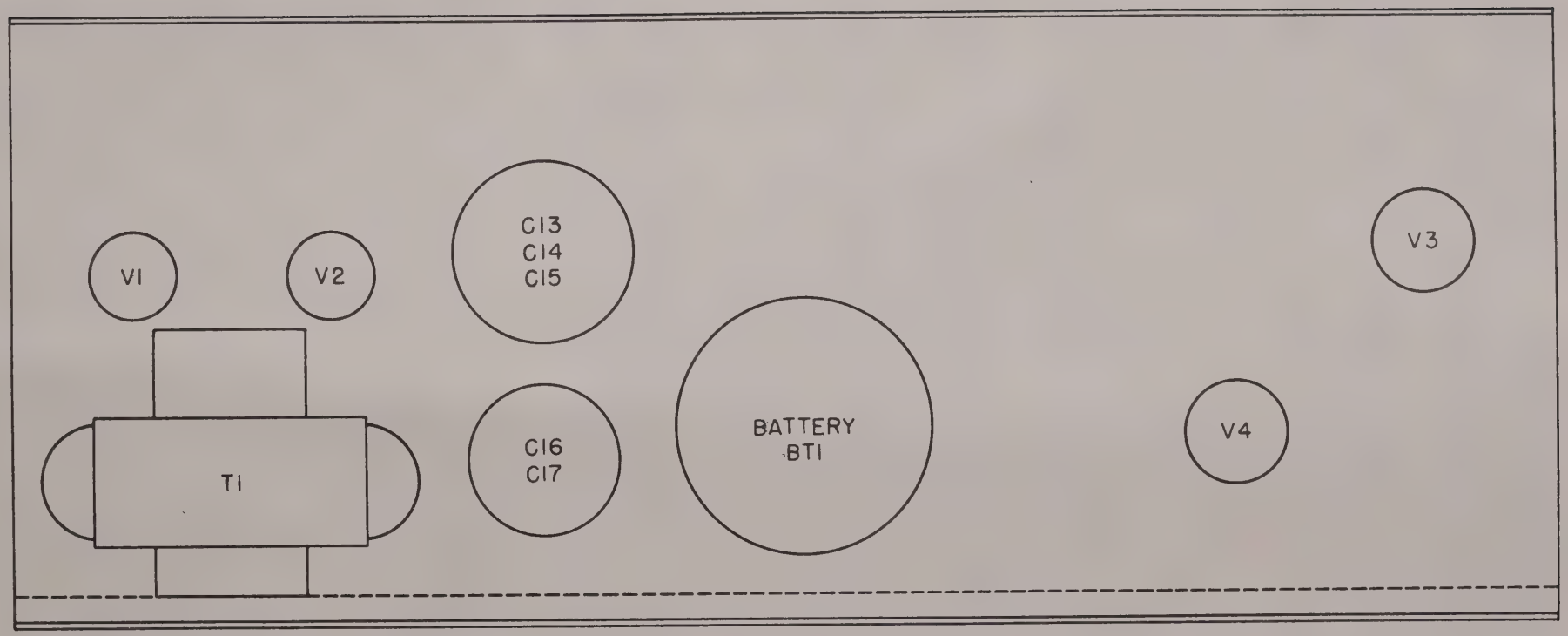
V. MAINTENANCE

VI. In general, the Model 870, DYNAMIC BETA TRANSISTOR TESTER will give long uninterrupted service. The Model 870 is a complex and specialized instrument. No repair beyond tube replacement should be attempted. If an instrument cannot be repaired by a tube replacement, it is recommended that the instrument be returned to the factory or any authorized Hickok service station.

1. Fuse Replacement

In the event of fuse failure, the instrument should be checked for shorts before a new fuse is installed. For fuse replacement, use .5A SLOW BLOW value only.

Figure #8 is included to aid in locating tubes for replacement.



LOCATION OF TUBES
FIG. - 8

VI. PARTS LIST

Reference designations have been assigned to identify all parts used in this instrument. An asterisk designates a part which should be replaced by authorized Hickok repair stations or factories. It is therefore recommended that the entire instrument be returned for repair if trouble exists with such a part.

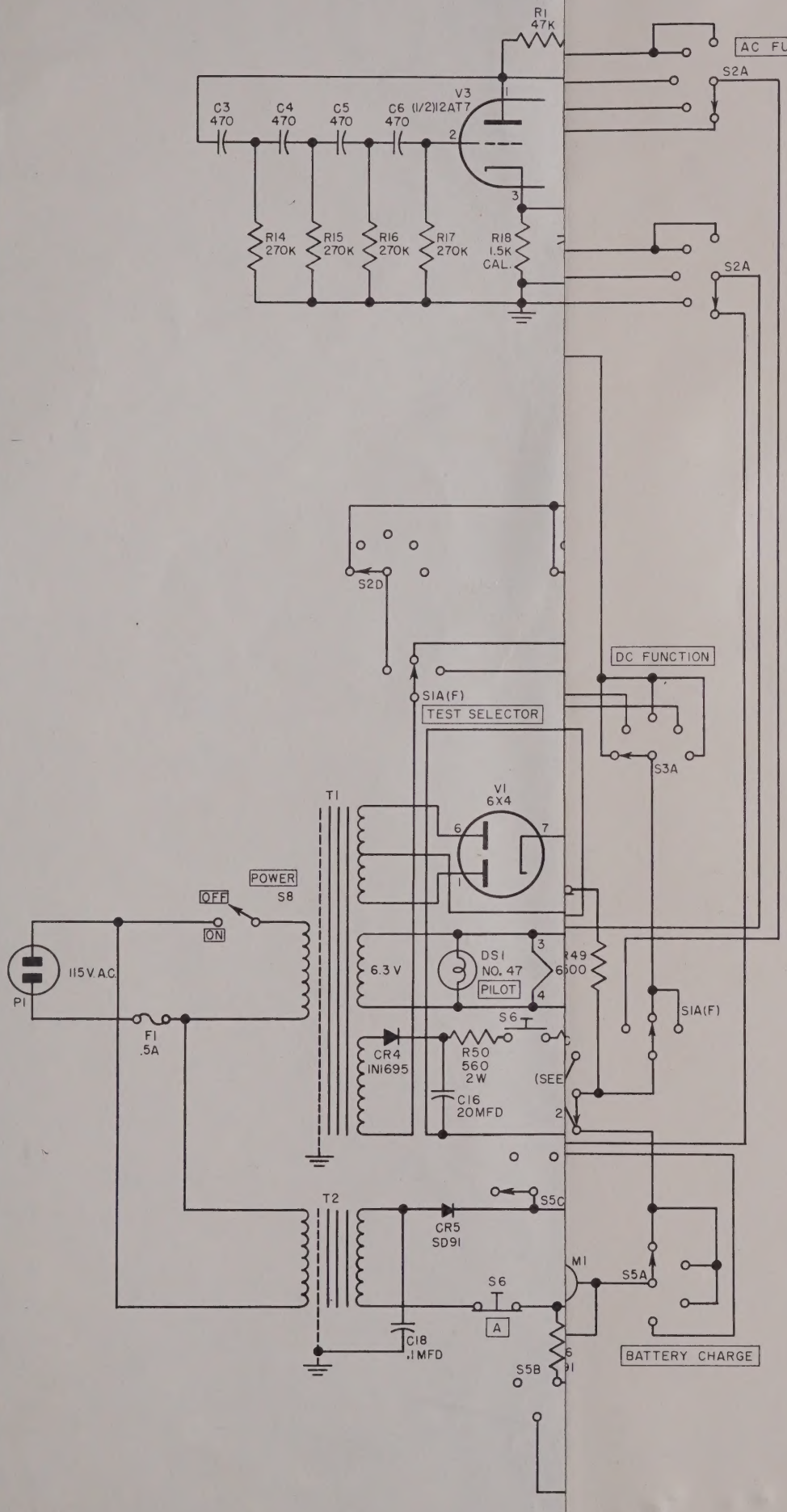
In ordering parts, refer to the current parts price list for this instrument. Prices are subject to change without notice, and the minimum billing charge is $3.50.

REF. DESIG.	NAME AND DESCRIPTION	HICKOK PART NO.
A1	INDEX ROLLER ASSEMBLY:	9600-33
BT1	BATTERY: nom. voltage 6 volts, 800 MA. H.	2210-27
BT2	BATTERY: nom. voltage 6 volts, 80 MA. H.	2210-28
C1, C2	CAPACITOR, FIXED, CERAMIC: .005μf, -0 +100%, disc type	3110-7
C3 thru C6	CAPACITOR, FIXED, MICA: 470μμf, 10%, 500 volts	3095-8
C7, C8	Same as C1	
C9 thru C11	CAPACITOR, FIXED, ELECTROLYTIC: 25μf, 25 volts	3085-110
C12	CAPACITOR, FIXED, CERAMIC: .1μf, disc type, 75 volts	3110-115
C13 thru C15	CAPACITOR, FIXED, ELECTROLYTIC: 20-20-20μf, 450 volts, lug terminals	3085-56
C16, C17	CAPACITOR, FIXED, ELECTROLYTIC: 20-20μf, 450 volts, lug terminals	3085-78
C18	CAPACITOR, FIXED, PLASTIC: .1μf, 200 volts	3105-210
C19	CAPACITOR, FIXED, PLASTIC: .5μf, 200 volts	3105-206
C20	Same as C1	
CR1 thru CR3	CRYSTAL: 1N34AS	3870-78
CR4	CRYSTAL: 1N1695	3870-49
CR5, CR6	CRYSTAL: type SD91	3870-41
DS1	LAMP: #47 G.E., 6-8 volts, .15 amp, miniature bayonet base	12270-12
E1, E2	BINDING POST: screw type, blue	2360-88
E3, E4	BINDING POST: screw type, green	2360-89
E5, E6	BINDING POST: screw type, yellow	2360-90
F1	FUSE: 1/2 amp, SLO-BLO, no pigtails	6900-15
M1	METER:	680-301
MP1	BUTTON: push, black	2920-7
MP2	BUTTON: push, red	2920-8
MP3 thru MP9	KNOB ASSEMBLY: with pointer, bar type	11500-11
MP10, MP11	KNOB: black phenolic, pelican	11505-55
MP12, MP13	KNOB: black phenolic, 1/4" molded hole	11505-72
P1	CORD: AC line	3675-1
P2	PLUG: banana, blue	16525-177
P3	PLUG: banana, yellow	16525-179
P4	PLUG: banana, green	16525-178
Q1	TRANSISTOR: 2N456	20861-3
R1	RESISTOR, FIXED, COMPOSITION: 47K ohms, 5%, 1/2 watt	18413-471
R2, R3	RESISTOR, FIXED, COMPOSITION: 100K ohms, 5%, 1/2 watt	18414-101
R4	RESISTOR, FIXED, COMPOSITION: 330K ohms, 10%, 1/2 watt (CAL)	18414-332
R5	RESISTOR, FIXED, COMPOSITION: 1 megohm, 10%, 1/2 watt	18415-102
R6	RESISTOR, VARIABLE: 25K ohms, 10%, 1/2 watt, screwdriver slot (AC BETA CAL)	40300-253
R7, R8	Same as R4	
R9, R10	RESISTOR, FIXED, COMPOSITION: 470 ohms, 5%, 1/2 watt	18411-471
R11	RESISTOR, FIXED, COMPOSITION: 470 ohms, 10%, 1/2 watt	18411-472
R12, R13	RESISTOR, FIXED, COMPOSITION: 1000 ohms, 10%, 1/2 watt	18412-102
R14 thru R17	RESISTOR, FIXED, COMPOSITION: 270K ohms, 5%, 1/2 watt	18414-271
R18	RESISTOR, FIXED, COMPOSITION: 1500 ohms, 5%, 1/2 watt (CAL)	18412-151
R19	RESISTOR, FIXED, COMPOSITION: 1800 ohms, 10%, 1/2 watt	18412-182
R20	RESISTOR, FIXED, FILM: 99K ohms, 1%, 1/2 watt	18537-171
R21	RESISTOR, VARIABLE: 250 ohms, 10%, 1/2 watt, screwdriver slot (INT. CAL. ADJ.)	40300-251
R22	Same as R18	
R23	RESISTOR, FIXED, FILM: 1000 ohms, 1%, 1/2 watt	18537-77
R24	RESISTOR, FIXED, FILM: 49K ohms, 1%, 1/2 watt	18537-170
R25	RESISTOR, FIXED, COMPOSITION: 22K ohms, 10% 1/2 watt	18413-222

REF. DESIG.	NAME AND DESCRIPTION	HICKOK PART NO.
R26	RESISTOR, FIXED, FILM: 20.4 ohms, 1%, 1/2 watt	18537-280
R27	RESISTOR, FIXED, COMPOSITION: 220 ohms, 10%, 1/2 watt	18411-222
R28	RESISTOR, FIXED, FILM: 111 ohms, 1%, 1/2 watt	18537-172
R29	RESISTOR, FIXED, FILM: 11.1 ohms, 1%, 1/2 watt	18537-167
R30	RESISTOR, FIXED, COMPOSITION: 51 ohms, 5%, 1/2 watt	18410-511
R31	RESISTOR, FIXED, FILM: 195K ohms, 1%, 1/2 watt	18537-104
R32	RESISTOR, FIXED, WIREWOUND: 1 ohm, 1%, 5 watts	18575-477
R33	RESISTOR, FIXED, FILM: 10 ohms, 1%, 1 watt	18696-101
R34	RESISTOR, VARIABLE: 1250 ohms, Part of R43, DUAL RESISTOR, VARIABLE	16925-364
R35	Same as R24	
R36	RESISTOR, FIXED, FILM: 666 ohms, 1%, 1/2 watt	18537-169
R37	Same as R2	
R38	RESISTOR, FIXED, COMPOSITION: 120K ohms, 10%, 1/2 watt	18414-122
R39	RESISTOR, FIXED, FILM: 19K ohms, 1%, 1/2 watt	18537-6
R40	RESISTOR, VARIABLE: 2 megohms, 20%, 1/2 watt, screwdriver slot (Ic ADJ. AC)	40300-205
R41	RESISTOR, FIXED, COMPOSITION: 2700 ohms, 10%, 2 watts	18432-272
R42	Same as R19	
R43	RESISTOR, VARIABLE: 25K ohms, Part of R34, DUAL RESISTOR, VARIABLE (DC BETA CAL)	
R44	RESISTOR, FIXED, COMPOSITION: 2200 ohms, 10%, 2 watts	18432-222
R45	RESISTOR, FIXED, FILM: 20 ohms, 1%, 1/2 watt	18537-168
R46	RESISTOR, FIXED, FILM: 200 ohms, 1%, 1/2 watt	18537-76
R47	RESISTOR, FIXED, FILM: 100 ohms, 1%, 1/2 watt	18537-96
R48	RESISTOR, FIXED, FILM: 50 ohms, 1%, 1/2 watt	18537-65
R49	RESISTOR, FIXED, FILM: 500 ohms, 1%, 1/2 watt	18537-58
R50	RESISTOR, FIXED, COMPOSITION: 560 ohms, 10%, 2 watts	18431-562
R51	RESISTOR, FIXED, COMPOSITION: 100 ohms, 10%, 1/2 watt	18411-102
R52	RESISTOR, FIXED, COMPOSITION: 1500 ohms, 10%, 1/2 watt	18412-152
R53	RESISTOR, FIXED, COMPOSITION: 100 ohms, 5%, 1/2 watt (20 resistors wired in series)	18411-101
R54	RESISTOR, FIXED, COMPOSITION: 47 ohms, 10%, 2 watts	18430-472
R55	RESISTOR, FIXED, WIREWOUND: 33 ohms, 10%, 5 watts	18575-247
R56	RESISTOR, FIXED, COMPOSITION: 820 ohms, 10%, 1 watt	18421-822
R57	RESISTOR, VARIABLE: 100 ohms, 10%, 2 watts, screwdriver slot (VCE ADJ.)	40100-101
R58	RESISTOR, VARIABLE: 250 ohms, 10%, 2 watts, screwdriver slot (1C ADJ. DC)	40100-251
R59	Same as R20	
R60	RESISTOR, FIXED, WIREWOUND: 47 ohms, 10%, 5 watts	18575-248
R61	Same as R9	
R62	RESISTOR, FIXED, COMPOSITION: 2200 ohms, 10%, 1/2 watt	18412-222
R63	RESISTOR, FIXED, COMPOSITION: 150 ohms, 5%, 1/2 watt	18411-151
S1	SWITCH, ROTARY: 4 section, 3 position (TEST selector)	19912-416
S2	SWITCH, ROTARY: 4 section, 5 position (AC FUNCTION selector)	19912-417
S3	SWITCH, ROTARY: 4 section, 5 position (DC FUNCTION selector)	19912-418
S4	SWITCH, ROTARY: 3 section, 2 position (TYPE selector)	19912-415
S5	SWITCH, ROTARY: 3 section, 4 position (BATTERY CHARGE selector)	19912-413
S6	SWITCH: 2 push button type (Operate)	19910-144
S7	SWITCH, ROTARY: 1 section, 21 position (COLLECTOR VOLTAGE)	19912-414
S8	SWITCH, TOGGLE: SPST, 3 amp, 125 volts (POWER, ON, OFF)	19911-71
S9	Part of S6 (Multiplier)	
T1	TRANSFORMER: Power	20800-235
T2	TRANSFORMER: Battery Charge	20800-236
V1	ELECTRON TUBE: 6 x 4	20875-68
V2	ELECTRON TUBE: OA2	20875-78
V3	ELECTRON TUBE: 12AT7	20875-77
V4	ELECTRON TUBE: 6AW8	20875-138
W1	LEAD ASSEMBLY: blue	12450-341
W2	LEAD ASSEMBLY: green	12450-342
W3	LEAD ASSEMBLY: yellow	12450-343

REF. DESIG.	NAME AND DESCRIPTION	HICKOK PART NO.
XDS1	SOCKET: Pilot light	19350-133
XF1	HOLDER: for fuse, 3 AG type	8825-83
XQ1	SOCKET: transistor	19350-369
XQ2, XQ3	SOCKET: transistor, mica filled	19350-361
XV1, XV2	SOCKET: 7 pin miniature, bottom mtg.	19350-155
XV3, XV4	SOCKET: 9 pin miniature, bottom mtg.	19350-154
	CHART: data roll	Semi-annual
	BOOKLET: instructions	2490-583

ALT.	DRAWING NUMBER
	902-469 W



NOTE:

1. UNLESS OTHERWISE INDICATED, RESISTANCES ARE IN OHMS (Ω), CAPACITANCES ARE IN MMF.

   * R53 IS COMPOSED OF 20 (100Ω) RESISTORS WIRED IN SERIES.

2. ▭ = EQUIPMENT PANEL MARKING.

   ⊘ = SCREWDRIVER ADJUST.

3. SWITCHES:
   - S1 = TEST SELECTOR
   - S2 = A.C. FUNCTION SELECTOR
   - S3 = D.C. FUNCTION SELECTOR
   - S4 = TYPE SELECTOR
   - S5 = BATTERY CHARGE SELECTOR
   - S6 = OPERATE
   - S7 = COLLECTOR VOLTAGE
   - S8 = POWER
   - S9 = MULTIPLIER

4. SWITCH DECKS ARE IDENTIFIED BY LETTERS "A", "B", "C", ETC.
   (F) = FRONT CONTACTS.
   (R) = REAR CONTACTS.

5. RX = APPROXIMATELY 150Ω, 1/2W.

SCHEMATIC WIRING DIAGRAM--MODEL 870

ALT.	DRAWING NUMBER
	902-469 W

NOTE:
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R & C SYMBOLS			
LAST USED		NOT USED	
R63	C20		

SCHEMATIC WIRING DIAGRAM--MODEL 870